IOWA WASTEWATER FACILITIES DESIGN STANDARDS

CHAPTER 18B

ACTIVATED SLUDGE BIOLOGICAL TREATMENT

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18B.1 GENERAL

18B.1.1 Applicability

This chapter is applicable to construction, installation or modification of any disposal system required to obtain a construction permit from this Department under the Iowa Code Section 455B.183 and 900--64.2 of the Iowa Administrative Code.

18B.1.2 Variances [900--64.2(9)"c" I.A.C.]

When engineering justification satisfactory to the executive director is provided substantially demonstrating that variation from the design standards or siting criteria will result in either: at least equivalent effectiveness while significantly reducing cost, or improved effectiveness, such a variation from design standards or siting criteria may be acceptable by the executive director.

18B.1.3 Explanation of Terms

The terms "shall" or "must" are used in these standards when it is required that the standard be used. Other terms such as "should" and "recommended" indicate desirable procedures or methods which should be considered but will not be required.

18B.2 PROCESS SELECTION

18B.2.1 Applicability

The activated sludge process, and its various modifications, may be used to treat wastewater which is amenable to biological treatment.

18B.2.2 Operational Requirements

The activated sludge process requires close attention and competent operating supervision. Facilities and appurtenances, including suitable laboratory apparatus, for routine control and testing shall be provided at all activated sludge plants.

18B.2.3 Specific Process Selection

The activated sludge process and its modifications may be employed to accomplish varied degrees of removal of suspended solids and reduction of carbonaceous and nitrogenous oxygen demand. Choice of the process most applicable will be influenced by the proposed plant size, type of waste to be treated, treatability of waste, degree and consistency of treatment required and local factors. All designs shall provide for flexibility in operation. All plants over 1 MGD at AWW flow should be designed to be operable in more than one mode. Seasonal organic loadings and significant wet weather flow increases are factors that affect mode of operation.

18B.3 PRETREATMENT

When primary settling tanks are not used, effective removal or exclusion of grit, debris, excessive oil or grease, and comminution or screening of solids shall be accomplished prior or the activated sludge process.

Where primary settling is used, it may be desirable to provide for discharging raw sewage directly to the aeration tanks to facilitate plant startup and initial operation.

18B.4 AERATION

18B.4.1 Basis of Design

In addition to the requirements of Chapter 11, the basis of design for the proposed activated sludge process shall be prepared by the engineer and included in the facilities plan or submitted under separate cover for review and approval. The basis of design shall include a discussion of all design parameters used in sizing activated sludge treatment facilities including the following:

1. Mode of operation including discussion of process flexibility.

2. Influent wastewater characteristics and flows. Flows are to include ADW, AWW, MWW, and PHWW flows.

3. Temperature range of wastewater, including estimates of temperature losses through the treatment plant and subsequent effect on removal efficiencies.

4. Pretreatment of the waste.

5. Effects of variable hydraulic and organic loadings applied to the aeration basins and secondary clarifiers, particularly variations resulting from infiltration/inflow to the system.

6. Anticipated mixed liquor suspended solids concentration to be maintained in the aeration basin.

7. Aeration time.

8. Oxygen transfer and mixing requirments at ADW, AWW, and MWW flows.

9. Sludge recirculation and wasting (ranges and average values), including proposed method of control and anticipated typical operating mode.

10. Design calculations for oxygen requirements, blower or aerator capacity, aeration basin and clarifier sizing, clarifier solids loading, and treatment efficiency shall be submitted for review.

18B.4.2 Capacities and Permissible Loadings

The size of the aeration tank shall be determined by full scale experience, pilot plant studies, and/or rational calculations based mainly on food to microorganism ratio, solids retention time, and mixed liquor suspended solids levels. Other factors such as size of treatment plant, diurnal load variations, and degree of treatment required shall also be considered.

Table 1 represents typical design parameters for domestic wastewater. Design parameters differing form those is Table 1 shall reference actual operating plants or pilot plant studies. The design parameters in Table 1 apply to plants receiving peak to average diurnal organic load ratios ranging from about 2:1 to 4:1. The Department may approve organic loading rates that exceed those specified in Table 1 if flow equalization is provided to reduce the diurnal peak organic load.

Single stage of two stage activated sludge systems designed to remove ammonia shall maintain adequate alkalinity concentrations and a pH level between 7.2 and 8.4. Chemical feed equipment shall be provided if necessary. Flow equalization shall be considered where necessary to limit TKN peaks resulting from industrial waste. For two stage systems, carbonaceous BOD_5 concentration to the second stage should be limited to 20-50 mg/l. A bypass around the first stage shall also be provided to allow discharge of raw or primary settled sewage to the second stage aeration tank as needed for process control.

Due to the dilute nature of some design load concentrations, it may be necessary to require a minimum hydraulic detention time to insure that the colloidal, finely suspended and dissolved organics are absorbed by the activated sludge. This minimum hydraulic detention time shall be based on the design flow (AWW) plus the return sludge flow and shall not be less than 60 minutes.

18B.4.3 Aeration Tanks

18B.4.3.1 Multiple Units

Multiple units shall be provided in accordance with chapter 14 of these Standards. Tanks shall be designed so that each tank may be dewatered and operated independently.

TABLE 1

TYPICAL AERATION TANK LOADINGS AND DESIGN PARAMETERS

Process	Solids Retention * Time-Days	Maximum Aeration Tank Organic Loading* lb. Bod_5/1000 cu. Ft./day	F/M Ratio* lb. BOD_5/lb.MLVSS/day	MLSS - $^{mg}/_{liter}$
Step Aeration, Complete Mix and Conventional	6 -15	40	.2 - .5	1000 – 3000
Contract stabilization	6 -15****	50****	.2 - .6****	1000 – 3000
Extended Aeration	20 - 30	15	.05 - .1	3000 – 5000
Combined Carbon Oxidation - Nitrification	15 - 25	15	.08 - .16	2000 – 5000
Carbonaceous Stage of Separate stage Nitrification	3 - 10	70	0.3 - 0.8	1000 – 2500
Nitrification Stage of Separate Stage Nitrification	15 - 25	10**	.05 - .20***	1000 – 3000

* Maximum – 30 day BOD_5 loading

** Lb. NH_3-N/$_{1000\ cu.}$ $^{ft.}$/$_{day}$

*** Lb. NH_3-N/$_{lbs.}$ ^{MLVSS}/$_{day}$

**** Total aeration capacity includes both contact and reaeration capacities.

18B.4.3.2 Tank Geometry

Tank dimensions shall not inhibit effective mixing or utilization of air. Liquid depths should not be less than 10 feet or more than 30 feet. The shape of the tank and the installation of aeration equipment shall provide for positive control of short circuiting through the tank.

18B.4.3.3 Freeboard and Froth Control

All aeration tanks shall have a freeboard of not less than 18 inches. Suitable water spray systems or other approved means of froth and foam control shall be provided if excessive foaming is anticipated. Otherwise, provisions for future installation of froth or foam control should be considered.

18B.4.3.4 Inlet and Outlet Control

Inlets and outlets for each aeration tank unit shall be suitably equipped with valves, gates, stop plates, weirs or other devices to permit balancing, proportioning and splitting of the flow to and from any unit and to maintain reasonably constant liquid level. The hydraulic elements of the system shall permit the peak hydraulic load to be carried with any single aeration tank out of service. This shall be done in accordance with the requirements of Section 14.4.9.3 of these design standards.

18B.4.3.5 Conduits

Channels and pipes carrying liquids with solids in suspension shall be designed to maintain self-cleansing velocities or shall be agitated to keep such solids in suspension at all design rates of flow. Provisions should be made to drain segments of channels when not in use.

18B.4.3.6 Winter Protection

Protection against freezing shall be considered during the design phase to ensure continuity of operation and performance in cold weather. Maximum utilization of earthen bank insulation should be considered to minimize heat losses.

18B.4.4 Aeration Equipment

18B.4.4.1 General

Aeration requirements depend upon mixing energy, BOD and nitrogen loading, degree of treatment, oxygen uptake rate, mixed liquor suspended solids concentration and sludge age. Aeration equipment shall be capable of maintaining a dissolved oxygen concentration of 2.0 mg/l in the aeration tanks at all times. Energy transfer shall be sufficient to maintain the mixed liquor solids in suspension.

In the absence of experimentally determined values, the design oxygen requirements for all activated sludge process shall be 1.1 lbs. $^{Oxygen}/_{lb}$. BOD_5 per day at the MWW flow plus 50% of the difference between the MWW flow and four-hour peak above that rate applied to the aeration tanks with the exception of the extended aeration process, for which the value shall be 1.8 lbs. oxygen/lb. peak 12-hour BOD_5.

In the case of nitrification, the oxygen requirement for oxidizing ammonia must be added to the above requirement for carbonaceous BOD_5 removal. The nitrogenous oxygen demand (NOD) shall be taken as 4.6 times the daily TKN content of the influent at MWW flow.

Additional oxygen shall supplied to meet the oxygen demands due to recycle flows – anaerobic digester supernatant, belt press filtrate, elutriates, etc.

Careful consideration should be given to maximizing oxygen utilization per unit power input. Unless flow equalization is provided, consideration should be given to designing the aeration system to match the diurnal organic load variations while economizing on power input.

18B.4.4.2 Diffused Air System

a. The design of the diffused air system to provide the oxygen requirements shall be prepared using calculations incorporating such factors as:

    1. Tank Depth;

    2. Alpha factor of wastes (taking into consideration aeration device characteristics and tank geometry);

    3. Beta factor of waste;

    4. Certified aeration device transfer efficiency;

5. Minimum aeration tank dissolved oxygen concentrations;

6. Critical wastewater temperature; and

7. Altitude of plant.

Treatment plants where the waste contains higher than 10% of industrial wastes shall experimentally determine the alpha and beta factors and shall have teast results calculations submitted to justify the factors. The basis of design shall include detailed computations for all diffused air systems taking into account the factors listed above.

b. The specified capacity of blowers or air compressors, particularly centrifugal blowers, should take into account that the air intake temperature may reach 104°F or higher and the pressure may be less than normal.

The specified capacity of the motor drive should also take into account that the take air may be -20°F or less and may requre oversizing of the motor or a means of reducing the rate of air delivery to prevent overheating or damage to the motor.

c. Multiple blowers shall be provided and so arranged and in such capacities as to meet the maximum total air demand with the single largest unity out of service. The design shall also provide for the ability to adjust air flow in proportion to the load demand of the plant. Aeration equipment shall be easily adjustable in increments and shall maintain solids suspension within these limits.

d. The air diffusion piping and diffuser system shall be capable of delivering air without excessive head loss with all available blowers on. Air diffusion piping includes all piping from the blower to the aeration basin. The spacing of diffusers must meet through the oxygenation requirements through the length of the channel or tank and should be designed to facilitate adjustments of their spacing without major revision to air header piping. Diffusers in any single assembly shall have substantially uniform pressure loss.

e. Individual assembly units of diffusers shall be equipped with control valves, preferably with indicator markings for throttling and for complete shut off. The arrangements of diffusers shall also permit their removal for inspection, maintenance and replacement without dewatering the tank and without shutting off the air supply in the tank, unless the dewatering aeration basins are 50% or less of the total aeration basin capacity.

f. Air filters shall be provided in numbers, arrangement and capacities to furnish at all times an air supply sufficiently free from dust to prevent clogging of the diffuser system used. Air filters will not be required where coarse bubble diffusers are used.

18B.4.4.3 Mechanical Aeration System

a. Oxygen Transfer Performance

The mechanisms and drive unit shall be designed for the expected conditions in the aeration tank in terms of the power performance. Certified testing shall verify mechanical aerator performance.

b. Design Requirements

The mechanical aeration system shall:

1. Maintain a minimum of 2.0 mg/l of dissolved oxygen in the mixed liquor at all times throughout the tank or basin.

2. Provide a liquid waste turnover time such that a minimum velocity of 1.0 fps is maintained at all points in the basin to provide adequate mixing and to prevent deposition of solids.

3. Be protected from excessive ice coating in inclement weather.

4. Include multiple unit installation designed to meet the maximum oxygen demand with the largest unit of service. Provision for rapid replacement must be provided. The design should also provide for varying the amount of oxygen transferred in proportion to the load demand on the plant. If depth of submersion is an important criteria, the aeration system shall be adjustable or the basin levels shall be readily controllable with regard to depth.

5. Spray protection in the form of must shields or high walls around tanks should be considered.

18B.5 RETURN SLUDGE EQUIPMENT

18B.5.1 Return Sludge Rate

The minimum permissible return sludge rate of withdrawal from settling tank is a function of the concentration of suspended solids in the mixed liquor entering it, the sludge volume index of these solids and the length of time these solids in the final settling tanks may be deleterious to both the aeration and the sedimentation phases of the activated sludge process, the rate of sludge return expressed as a percentage of the AWW design flow of sewage shall be variable between limits of 25 to 100 percent. This requirement shall apply to all activated sludge processes except extended aeration, single stage nitrification and the nitrification stage of separate stage nitrification where the return sludge rate shall be variable form 50 to 150 percent.

18B.5.2. Return Sludge Pumps

If motor driven return sludge pumps are used, the maximum return sludge capacity shall be obtained with the largest pump out of service. The rate of sludge return shall be varied by means of variable speed motors, drives, or other suitable means. A positive head should be provided on pump sunctions. Pumps shall have at least three inch suction and discharge openings.

If air lift pumps are used for returning sludge from each settling tank, no standby unit shall be required provided that the design of the air lifts is such as to facilitate their rapid and easy cleaning. Air lifts should be at least three inches in diameter.

18B.5.3 Return Sludge Piping

Suction and discharging piping should be at least four inches in diameter and should be designed to maintain a velocity of not less than 1.0 feet per second when return sludge facilities are operating at normal (25 – 150%) return sludge rates. Devices for observing, measuring, sampling and controlling return activated sludge flow from each settling tank shall be provided, as outlined Section 16.4.2.4.

18B.5.4 Waste Sludge Control

Waste sludge control facilities should have a maximum capacity of not less than 25 percent of the AWW flow and function satisfactorily at rates of 0.5 percent of the average dry weather flow or a minimum of 10 gallons per minute, whichever is larger. Means for observing, measuring, sampling and controlling waste activated sludge flow shall be provided. It is desirable to have separate waste sludge equipment so that sludge return is not interrupted.